

AMENDMENTS TO THE SPECIFICATION

Please amend the Specification as set forth below.

Please replace the title with the following amended title:

Apparatus and Method for Supplemental Control of an Automatic Sprinkler System

Please replace paragraph [0001] with the following amended paragraph:

[0001] This application claims the benefit of U.S. Provisional Patent Application serial No. 60/421,963, filed Oct. 28, 2002, entitled "System for Environmental Monitoring and Control," of Dale K. Hitt, which application is incorporated herein by reference in its entirety. This application is related to the following concurrently filed and commonly assigned U.S. patent applications: U.S. Patent Application Serial No. 10/692,532, entitled "Wireless Sensor System for Environmental Monitoring and Control," of Dale K. Hitt; U.S. Patent Application Serial No. 10/692,476, entitled "Distributed Environmental Control in a Wireless Sensor System," of Dale K. Hitt; U.S. Patent Application Serial No. 10/692,518, entitled "Scheduled Transmission in a Wireless Sensor System," of Dale K. Hitt; U.S. Patent Application Serial No. 10/693,017, entitled "Wireless Sensor Probe," of Dale K. Hitt et al.; and U.S. Patent Application Serial No. 10/692,519, entitled "RF Based Positioning and Intrusion Detection using a Wireless Sensor Network," of Dale K. Hitt et al.

Please replace paragraph [0045] with the following amended paragraph:

[0045] Wireless environmental monitoring and control system 130 can also include other nodes for providing other supporting functions. Referring to Figure 2, the sensor and actuator nodes within system 130 also communicate with nodes with monitoring capabilities only. For example, a local monitor node 166 is provided for communication

with any one of the sensor and actuator nodes. Local monitor node 166 can be coupled to a personal computer 188 for receiving, storing and/or processing data received from the sensor nodes or actuator nodes. A gateway node 168 can also be provided to facilitate access to a local area network or the internet. In the present embodiment, gateway node 168 is connected through a local area network 192 to a computer 190 which provides access to the Internet or an intranet. In this manner, monitoring and/or control of system 130 can be facilitated remotely through a local area network through the Internet. A repeater node 177 is also provided. Repeater node 177 does not provide other functions and act only to relay messages between the nodes in system 130. In one embodiment, a sensor node or an actuator node can also act as a repeater node for relaying messages between other nodes. System 130 can also include a user interface node (not shown) whereby a user can access the network of sensor and actuator nodes for reading data and for providing control.

Please replace paragraph [0063] with the following amended paragraph:

[0063] Figure 3 is a block diagram illustrating the operation of a wireless environmental monitoring and control system according to one embodiment of the present invention. In Figure 3, wireless nodes 350-366 in environmental monitoring and control system 330 are geographically arranged such that the antenna patterns (not shown) associated with each wireless node overlap to create a coverage area. Figure 3 shows the distribution of wireless nodes 354, 356, 360 and 362 in a building 351 and other wireless nodes 350, 352, 358, 364, 366 outside the building 351. In this manner, environmental monitoring and control system 330 enables a wireless network node 364 (a sensor node) associated with the coverage area to communicate with another wireless node 352 (an actuator node) in the coverage area via several possible communication paths. For instance, wireless node 364 may communicate with wireless node 352 via several different communication paths, each path defined by one or more wireless nodes within the coverage area. For example, in Figure 3, sensor node 364 may communicate with

actuator node 352 via a wireless node 358 which can be a sensor node, an actuator node, or a monitoring node. Alternately, sensor node 364 may communicate with actuator node 352 through a series of intermediate nodes 362, 356, 354 and 350. In this manner, the range of each wireless node can remain small to limit power consumption while ensuring a wide coverage area for system 300.

Please replace paragraph [0064] with the following amended paragraph:

[0064] Figure 4 is a flow chart illustrating the operation of each wireless node for receiving and transmitting messages within the environmental monitoring and control system according to one embodiment of the present invention. In the present embodiment, the transceivers in the wireless nodes of the system are synchronously activated to establish end-to-end network connectivity (step 402). The wireless transceiver receives an incoming message via the antenna (step 404). The transceiver receives the incoming message, modifies the received signal, and passes the modified signal onto the processor. The processor evaluates the message to determine the intended recipient (step 406). If the intended recipient is the wireless node itself, the processor then prepares the appropriate response (step 408). The response may include collecting data from the sensor or providing a control signal to the actuator. If the intended recipient is not the wireless node itself, the processor then prepares the message to be re-transmitted to the intended recipient. Specifically, the processor of the wireless node determines the best route to the destination (step 410) and retransmits the message as necessary (step 412). The best route can be determined by the smallest number of intermediate nodes, by nodes with the maximum power available and by most reliable links. The wireless node awaits confirmation of receipt of the message (step 414). When the confirmation is not received, the wireless node attempts to retransmit the message by returning to step 410. When confirmation is received, the processing for the message is completed (step 416).

Please replace paragraph [0087] with the following amended paragraph:

[0087] According to yet another embodiment of the present invention, the environmental monitoring and control system is configured for occupancy detection or intrusion detection. In this embodiment, the RF transceivers of the wireless nodes are used as sensors to detect the movement of objects in the regions between wireless nodes. Figure 12 is a schematic diagram illustrating the use of the environmental monitoring and control system of the present invention for occupancy detection. The occupancy detection system comprises a plurality of wireless nodes as shown by wireless nodes 1200 to 1213 on Figure 12. Referring to Figure 12, an object 1220 is in a position between a wireless node 1206 and a wireless node 1212, an object 1221 is positioned between the wireless nodes 1206 and 1207, and an object 1222 is positioned between nodes 1201, 1202, 1206 and 1207. This position affects the measured RF power level of signals sent between these [[the two]] nodes. By measuring the RF power levels of signals sent between all of the nodes in the network and identifying large changes, it is possible to estimate the location and motion of objects in the region. The detection can be further enhanced by correlating the measurements of the nodes to reduce false alarms and improve precision of the position estimate. To enhance the quality of the detection, it is desirable to know the physical location of each of the transceivers in the network. This can be measured during installation or automatically estimated from RF power measurements as detailed above.

Please replace paragraph [0054] with the following amended paragraph:

[0054] With an interconnected wireless network such as system [120] 130 that provides processing capabilities at every node, nodes on the network can distribute signal processing, storage and analysis function to better optimize the use of the network resources. A distributed environmental control system for efficient and effective system management is thus realized. By providing a distributed control, the operation of

wireless environmental monitoring and control system 130 can be flexible and various fail-safe can be realized.

Please replace paragraph [0079] with the following amended paragraph:

[0079] When the environmental monitoring and control system of the present invention is used for irrigation, it is desirable to have a sensor node that can easily be installed in the ground to measure soil moisture, temperature as well as other properties of the soil and air. FIG. 7 is a cross-sectional diagram illustrating a sensor node according to one embodiment of the present invention and the installation of the sensor node in the ground. Referring to FIG. 7, a sensor node 750 is inserted into the soil 754 ~~755~~. Sensor node 750 includes a collar 752 extends out from a housing or a probe body 751 of the sensor node for anchoring the sensor node above the soil. Also, collar 752 serves to protect the sensor node from encroachment by surrounding plants, reduce the buildup of water around the probe, and reduce grass shading of the probe. Collar 752 may be attached to sensor node 750 or it may be loose or free floating. Sensor node 750 also includes a gasket 756 that extends out from the surface of sensor body 751. Gasket 756 serves to increase the contact force with the surrounding soil improving the stability of the installed sensor node and reducing the possibility that water will flow down along the side of the sensor body. Gasket 756 is in the shape of a ring, such as a rubber ring. In the present embodiment, sensor node 750 further includes a gasket 758. Gasket 758 is a gasket structure with an angular shape. The angular gasket structure has a top portion facing the top of the probe body, a bottom portion facing the bottom of the probe body and a side portion having tapered width where the width decreases from the top portion to the bottom portion. Gasket 758 aids in the insertion of sensor node 750, but prevents the sensor node from being pushed up out of the soil by regular expansion cycles. In other embodiments, the sensor node may include only one gasket.

Please replace paragraph [0092] with the following amended paragraph:

[0092] In one embodiment, the two-wire control system interfaces sensors/auxiliary decision information to an existing automatic sprinkler system so that precise control of on/off and duration of individual zones in an irrigation cycle is attained. Figure 13 is a block diagram of an automatic sprinkler system 1300 incorporating the two-wire control system according to one embodiment of the present invention. Referring to Figure 13, sprinkler system 1300 includes a timer-based sprinkler controller 1302. Sprinkler controller 1302 provides irrigation control of zone no. 1 to zone no. N. Thus, sprinkler controller 1302 includes a first set of wires coupled to the zone control nodes 1 to N for providing the 24V drive signal to the respective valves no. 1 to N. A common line 1304 connects a common node ~~1304~~ 1305 to all the valves for establishing the common return path.

Please replace paragraph [0101] with the following amended paragraph:

[0101] In one embodiment, the sensing circuit 1308 comprises a voltage measurement circuit or a current measurement circuit coupled to either the control line or the common line. Figure 15A shows the ON-OFF sensing circuit 1308A comprising a voltage measurement circuit coupled to the control line #1 (labeled ZoneCtl #1), between the sprinkler controller 1302 and one connector of valve #1. Similarly, Figure 15B shows the ON-OFF sensing circuit 1308B comprising a voltage measurement circuit coupled to the common line (labeled Common 1304), between the sprinkler controller 1302 and the common connectors of valves #1 to #N. Figure 16A shows the ON-OFF sensing circuit 1308E comprising a current measurement circuit coupled to the control line #1 (labeled ZoneCtl #1), between the sprinkler controller 1302 and one connector of valve #1. Similarly, Figure 16B shows the ON-OFF sensing circuit 1308F comprising a current measurement circuit coupled to the common line (labeled Common 1304), between the sprinkler controller 1302 and the common connectors of valves #1 to #N. The detection of the voltage on the common line or the control lines can be achieved through the use

of a transistor or operational amplifier that saturates when the potential difference on the two contacts of the open relay exceed a specified threshold. Figure 15C shows a typical schematic of a voltage measurement circuit employing a transistor, and Figure 15D shows a typical schematic of a voltage measurement circuit employing an operation amplifier. Detection of the current in the common line or the control lines can be achieved either by an inductively coupled current detector or by measuring the voltage differential across an in-line resistor. Figure 16C shows a typical schematic of a current measurement circuit employing an in-line resistor where the voltage differential across this resistor represents the valve on-off state, and Figure 16D shows a typical schematic of a current measurement circuit employing an inductively coupled current detector where the current flowing in the coil represents the valve on-off state.

Please add the following new paragraphs after paragraph [0041] of the original application:

Fig. 15A illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 15B illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 15C illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 15D illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 16A illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 16B illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 16C illustrates a block diagram of an automatic sprinkler system according to the present invention.

Fig. 16D illustrates a block diagram of an automatic sprinkler system according to the present invention.